Nature Conservation 5: 1–11 (2013)
doi: 10.3897/natureconservation.5.4511
http://www.pensoft.net/natureconservation

RESEARCH ARTICLE

A peer-reviewed open-access journal
Nature Conservation
Launched to accelerate biodiversity conservation

Are the nesting probabilities of the red-backed shrike related to proximity to roads?

Federico Morelli[1]

1 *DiSTeVA, University of Urbino, 61029 Urbino, Italy*

Corresponding author: *Federico Morelli* (federico.morelli@uniurb.it)

Academic editor: *R. Julliard* | Received 14 December 2012 | Accepted 22 March 2013 | Published 13 November 2013

Citation: Morelli F (2013) Are the nesting probabilities of the red-backed shrike related to proximity to roads? Nature Conservation 5: 1–11. doi: 10.3897/natureconservation.5.4511

Abstract

Roads are a pervasive feature in the landscape, and their ecological effects on vertebrate wildlife have been well documented. The main types of effect described are mainly negative consequences on birds and other vertebrates. The major impact of roads on birds includes habitat fragmentation, traffic noise and direct mortality from road kills. However, some passerines, such as the Red-backed Shrike, seem to often use areas close to roads for nesting and hunting purposes.

The aim of this paper is to study the importance of road proximity for the selection of suitable shrubs for nesting by the Red-backed Shrike in the farmland landscapes of central Italy. To achieve this goal, the hierarchical partitioning procedures of Generalized Linear Models (GLM) are applied in order to quantify the relative effects of a number of independent variables.

At least 77% of the nests we identified were positioned less than 25 meters from roads. The mean distance from the nest to the nearest road was 12.9 ± 18.1 m. The analysis of the relative importance of each variable revealed that "road distance" is one of variables most associated with nesting probability in suitable shrubs. It is reasonable to argue that suitable shrubs and the presence of open spaces for hunting, both of which exist close to countryside roads, might represent the favourable components of the breeding habitat selections of Red-backed Shrikes. Our results can provide useful indications for census techniques and for the planning of conservation measures for the species in agricultural landscapes.

Keywords

Road, Lanius collurio, occurrence, nest, suitable shrub, GLM

Introduction

Roads constitute a pervasive feature in the landscape, and their ecological effects on vertebrate wildlife have been well documented (Van der Zande et al. 1980, Bennett 1991, Forman 1995, Forman and Alexander 1998, Spellerberg 1998, Forman and Deblinger 2000, Trombulak and Frissell 2000). However, the main types of effect have mainly negative consequences on birds and other vertebrates (Kociolek et al. 2011). The major impact of roads on birds includes habitat fragmentation during and after road construction (Reed et al. 1996), displacement caused by traffic noise (Reijnen et al. 1995a, 1995b, 1996, Forman and Deblinger 2000), and direct mortality from road kills (Mumme et al. 2000). Reduced reproductive success associated with increasing human interference has been also reported, although some birds seem to be unaffected by the presence of roads (Trombulak and Frissell 2000). For example, some passerines, such as the Red-backed Shrike, *Lanius collurio*, often seem to use areas close to roads for nesting and hunting purposes (Bechet et al. 1998, Morelli 2012, Morelli et al. 2012), possibly because the hedgerows and shrubs alongside roads can increase prey abundance and constitute good perches for hunting (Farkas et al. 1997; Tryjanowski et al. 2000).

The Red-backed Shrike is an endangered bird species whose populations have recently been in decline almost all over the world (Yosef 1994, PECBMS 2008). It is present in all regions of Italy, both as a regular migrant and a breeding species during the summer months (Foschi and Gellini 1987, Meschini and Frugis 1993, Dinetti 1997). The species mainly prefers to breed in the transition zones between woods and grassland, lines of trees, and the thick hedgerows that often border roads. They also use open farmland with shrub or tree cover as well as high meadows (Guerriere and Castaldi 2006, Morelli 2012, Morelli et al. 2012). The Red-backed Shrike is a carnivorous bird that primarily hunts invertebrates and insects, but also reptiles, amphibians, micromammals and other birds, using observation posts or perches for this purpose (Lefranc 1993).

The aim of this work is to study if the selection of suitable shrubs for nesting by Red-backed Shrike is related to road proximity in the farmlands of central Italy.

Materials and methods

The study was conducted in a breeding territory of the Red-backed Shrike in the River Foglia catchment area in central Italy (43°45'8.43"N, 12°37'47.10"E). The bird data was collected during the 2009 breeding season by recording the presence and occupancy for nesting of each suitable shrub in an area of 600ha. First, all of the contacts obtained within the study areas were recorded on detailed aerial photographs (scale 1:1000). Following methods used elsewhere and the census of the species in Italy (Brambilla et al. 2007; Morelli 2012), and by considering the marked territoriality of the species (Tryjanowski and Golawski 2004), a variation of the formal mapping procedure mentioned by Bibby et al. 1997 was used and adjusted to gathering informa-

tion on nest locations in the study area. When breeding behaviour was detected (particularly, males and females together, singing males, aggressive encounters, pairs showing courtship routines, copulating or any nesting behaviour), the observations were increased to identify the core of the breeding territory and the most commonly used shrubs. Inspections of the occupied shrubs to verify nest presence were carried out, but contact with the breeding individuals was minimised (Tryjanowski and Kuzniak 1999), thereby avoiding more invasive collection methods (egg number counts, breeding success, etc.). All suitable shrubs were equally surveyed in the search for nests. The metrics on nest position were collected later, when the breeding season was over.

Each shrub was digitised and classified as "suitable" according to previous ecology studies of this species in the same region (Guerriere and Castaldi 2006, Morelli 2012, Morelli et al. 2011). The following were considered:

- Suitable vegetal species: Blackthorn *Prunus spinosa*, Dog rose *Rosa canina*, Elm-leaf Blackberry *Rubus ulmifolius,* and Common Hawthorn *Crataegus monogyna*.
- Suitable plant size: minimum height of suitable shrubs (fixed empirically at a minimum of 0.5m, based on previous studies in the same area; Morelli unpublished data); and
- Suitable density of foliage: mainly the shrubs with dense foliage and a strong branch structure that is suitable for positioning and protecting the nest.

The suitable shrubs were classified as "occupied" (when a nest was found inside them) or "unoccupied". Only active nests were included in this analysis as "occupied".

All of the data collected was mapped by means of ArcGIS 9 tools (ESRI 2009), which are also useful for calculating the following environmental parameters: altitude; distance to nearest road; shrub shape; shrub surface; shrub density (the density of the shrubs was calculated as the number of suitable shrubs around the occupied suitable shrub in a fixed radius of 50m as this corresponds approximately to the typical territory of the species (Lefranc 1993; Olsson 1995)); distance to nearest shrub; landscape fragmentation (as edge-density of land-use); and coverage proportion of each land-use category around 50m of each suitable shrub. All of the digitised data was further corrected during the surveys in the field. The large patches that were comprised of two or more shrubs, or were too near to or were intersected by roads, were adjusted by means of data collected in the field and then divided. The roads that were present in the study area were classified as paved, unpaved and pathway. Vehicular traffic intensity was also calculated for the monitored roads in terms of cars/hour (Table 1).

The relationships between nesting on suitable shrubs and environmental parameters were examined using Generalized Linear Models (McCullagh and Nelder 1989), with the dependent variable (shrub occupancy) modelled by specifying the logistic (binomial) family. The proportion of land-use coverage was transformed using the arcsine of square root transformation, as suggested by the Box-Cox plot (Box and Cox 1964). In order to minimise the multi-collinearity of variables, the parameters (regressors) with the strongest correlation between them ($R>0.8$) were eliminated manually. All

Table 1. Environmental parameters used to describe the study area and buffer zone around the suitable shrubs and for modelistic purposes.

Parameter	Level or type	Details	Variable used as regressor for model procedures
Altitude	landscape	Altitude of suitable shrub (m asl)	Yes
Roads	landscape	Presence and type of roads (paved, unpaved, pathway)	No
Nearest road distance	landscape	Distance in m from suitable shrub to nearest road	Yes
Power lines	landscape	Presence of power lines	Yes
Edge-density	landscape	Sum of the perimeters of all polygons contained in the buffer zone per number of land-use typologies	Yes
Shrub density	landscape	Calculated in a fixed radius of 50m around each suitable shrub	Yes
Nearest shrub distance	landscape	Distance in m from suitable shrub to nearest shrub	Yes
Shrub surface	-	Surface of suitable shrub, m^2	Yes
Shrub shape	categorical	Classified as circle, rectangle or irregular	Yes
Traffic intensity	categorical	Cars/hour (classified then as low, medium, high)	No
Urban	land use	%	Yes
Forest	land use	%	Yes
Shrubs	land use	%	Yes
Uncultivated	land use	%	Yes
Badland	land use	%	Yes
Grassland	land use	%	Yes
Hedgerows	land use	%	Yes
Isolated trees	land use	%	Yes
Vineyards	land use	%	Yes
Olive	land use	%	Yes
Cultivated	land use	%	Yes

independent variables were standardised during the first run of the regression process in order to properly compare their coefficients. The decostand function of the vegan package in R was used and the "max" method was selected. This methodology works by transforming all variables in a range from 0 to 1, where the max values for each variable are 1 and the other values are calculated as a proportion thereof.

A stepwise backward procedure was followed in order to select the most significant variables using the Akaike Information Criterion (AIC) (Akaike 1974; Anon 1999). The predictive performance of the best model selected by the stepwise process was evaluated using a ROC plot and the AUC (area under the curve) (Fielding and Bell 1997). The AUC values ranged from 0.5 for models with no discrimination ability to 1 for the models with perfect discrimination.

In order to measure the effects of each independent variable on the occupancy of suitable shrubs, the hierarchical partitioning protocol (Chevan and Sutherland 1991) was used by means of HIER.PART package (Walsh and Mac Nally 2008) and allowed

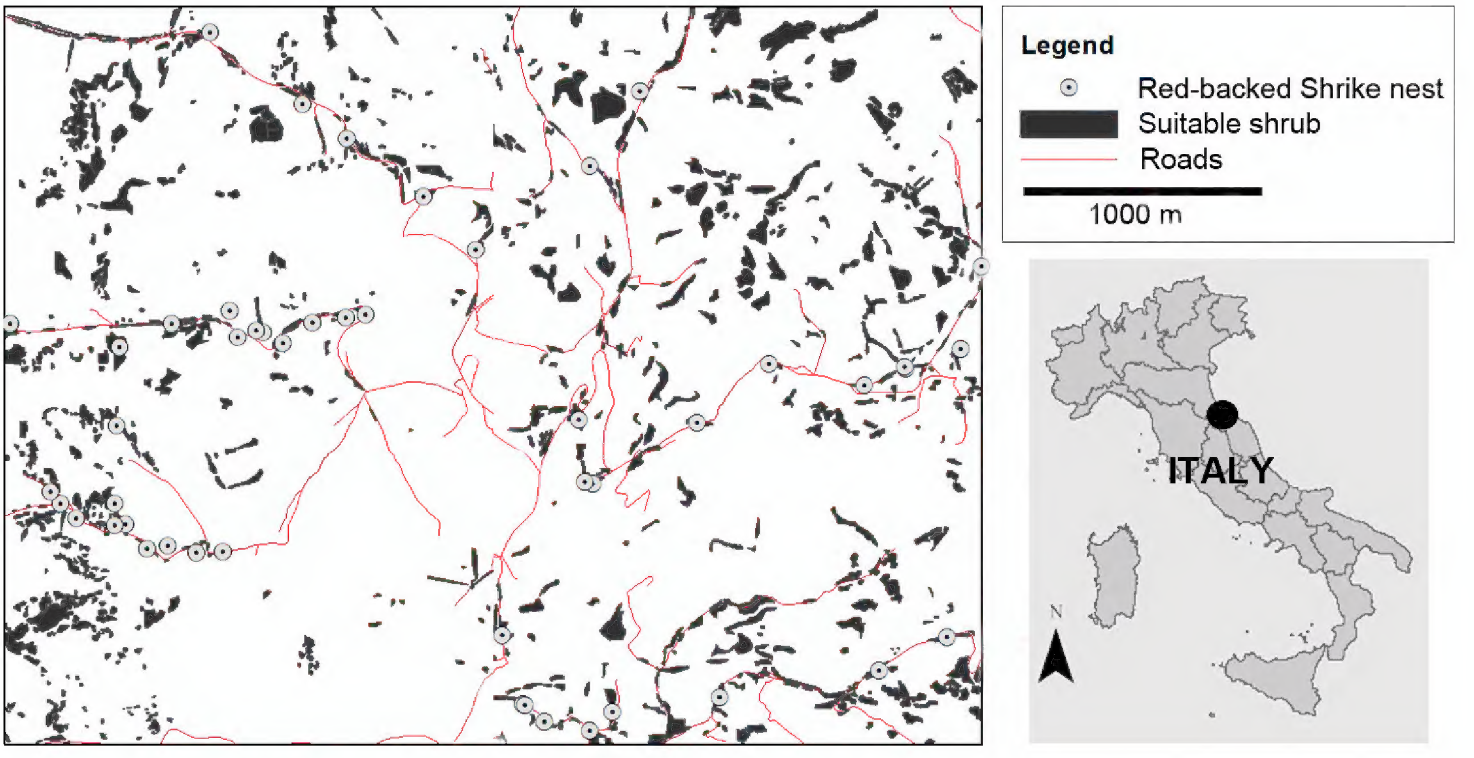

Figure 1. Suitable shrubs, roads and nests of the Red-backed Shrike in the study area in central Italy.

the estimation of both independent (I) and joint (J) explanatory power of each variable, considering all the 2K possible models (Mac Nally 2000). The relative importance values output is a numeric vector, named as the predictor variables, resulted from the sum of 'Akaike weights' over all models including the explanatory variable. All tests were performed using the R program (R Development Core Team 2011).

Results

The roads present in the study area were: 75% paved, 23% unpaved and 2% pathway. All of the roads were characterized by low vehicular traffic, with fewer than five cars per hour.

A total of 739 suitable shrubs were identified and mapped in the study area (Fig. 1). The density of these shrubs was 1.23 shrubs/ha, and they were mainly distributed in cultivated, uncultivated and grassland land-use typologies. Circa 34% of the total number (occupied and unoccupied) of suitable shrubs were less than 100 metres from the roads. We found 46 nests belonging to Red-backed Shrikes in the study area. All of these were located on suitable shrubs, with a density of 0.76 pairs/10 ha. There were no cases of more than one nest per shrub. The mean distance from the occupied suitable shrubs to the nearest road was 12.9m (with a maximum of 98 and a minimum of 0.2 m). In 77% of the cases, the nests were positioned less than 25m from roads (Fig. 1).

From the initial model (AUC: 0.88), which considered all of the environmental variables, was selected the best model, with a compromise between goodness of fit and model complexity (MacNally 2000). This model produced an AUC score of 0.83. The presence of nests of Red-backed Shrikes in suitable shrubs seemed to be well explained by the seven variables set out in Figure 2. There were four parameters related to spatial distribution and landscape heterogeneity (nearest road distance, shrub density, nearest

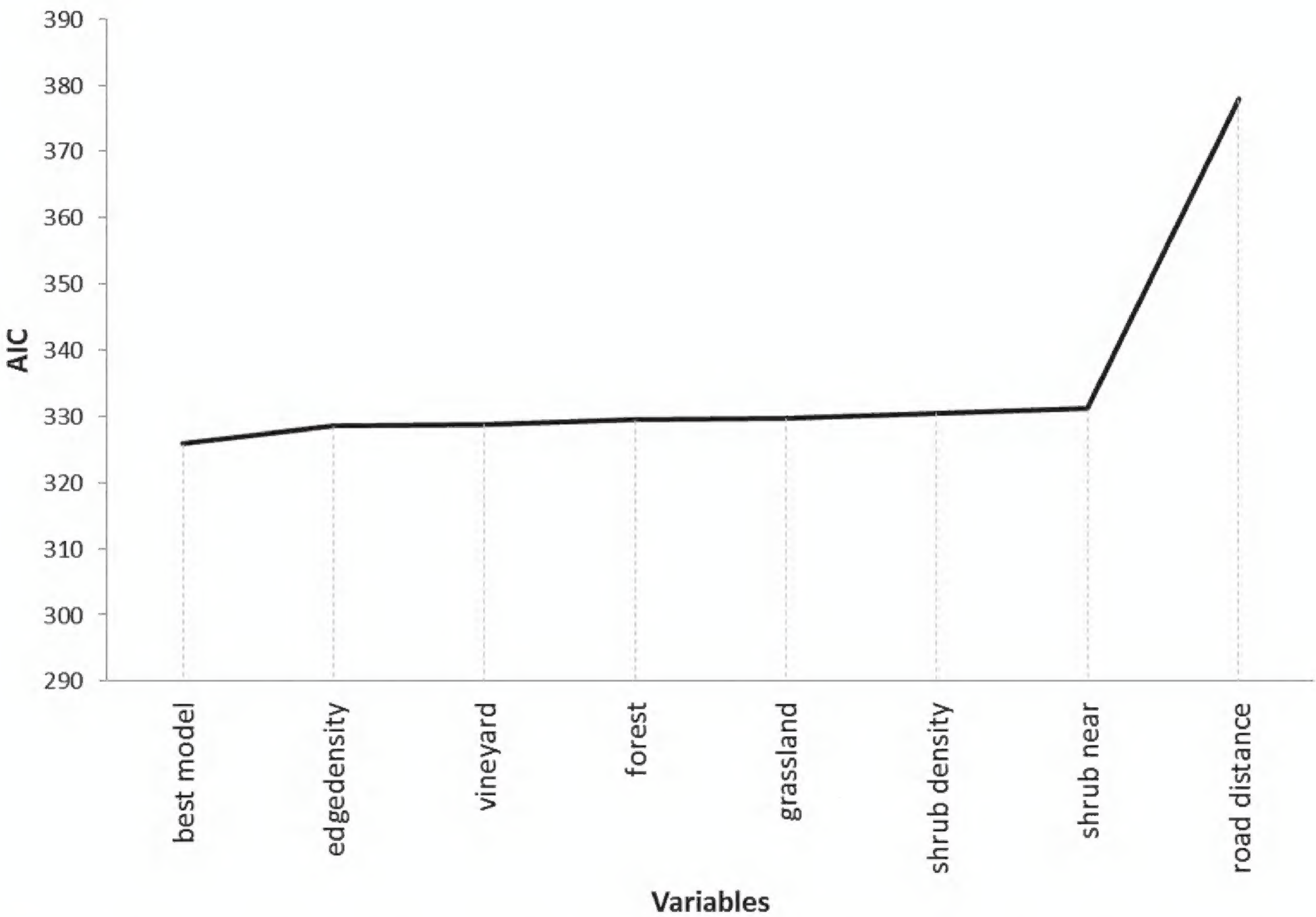

Figure 2. Change in the goodness of fit of the best model when deleting each environmental variable.

Table 2. Results of logistic regression for the best model related occurrence of Red-backed Shrike nests in suitable shrubs with environmental parameters in central Italy. The table shows the significant variables selected after a stepwise backward procedure using AIC criteria (p-values in bold). The AIC value of the best model was 327.9, which was the lowest figure if compared with the AIC value obtained by the initial model (336.2). AUC of best model: 83.0%.

Parameter	Estimate	SE	Z value	*p*-values
Farmlands (n=160)				
Nearest road distance	-0.0253	0.0052	-4.804	**1.55e-06** ***
Shrub density	-0.3096	0.1491	-2.077	**0.0378** *
Nearest shrub distance	-0.0317	0.0157	-2.019	**0.0435** *
Edge-density	3.2373	1.9718	1.642	0.1006
Vineyards	3.3881	1.8579	1.824	0.0682 **.**
Forest	-1.2244	0.6812	-1.797	0.0723 **.**
Grasslands	0.8670	0.4341	1.997	**0.0458** *
Intercept	-1.2114	0.5796	-2.090	**0.0366** *

Significance codes: '***' p<0.001, '**' p<0.01, '*' p<0.05, '.' p<0.1

shrub and edge-density), and three related to land-use typologies (vineyard, forest and grassland) (Table 2).

However, the relative importance of each variable on the probability of the occurrence of Red-backed Shrike nests on suitable shrubs was different. The result of the hierarchical partitioning procedures highlighted the importance of road distance for

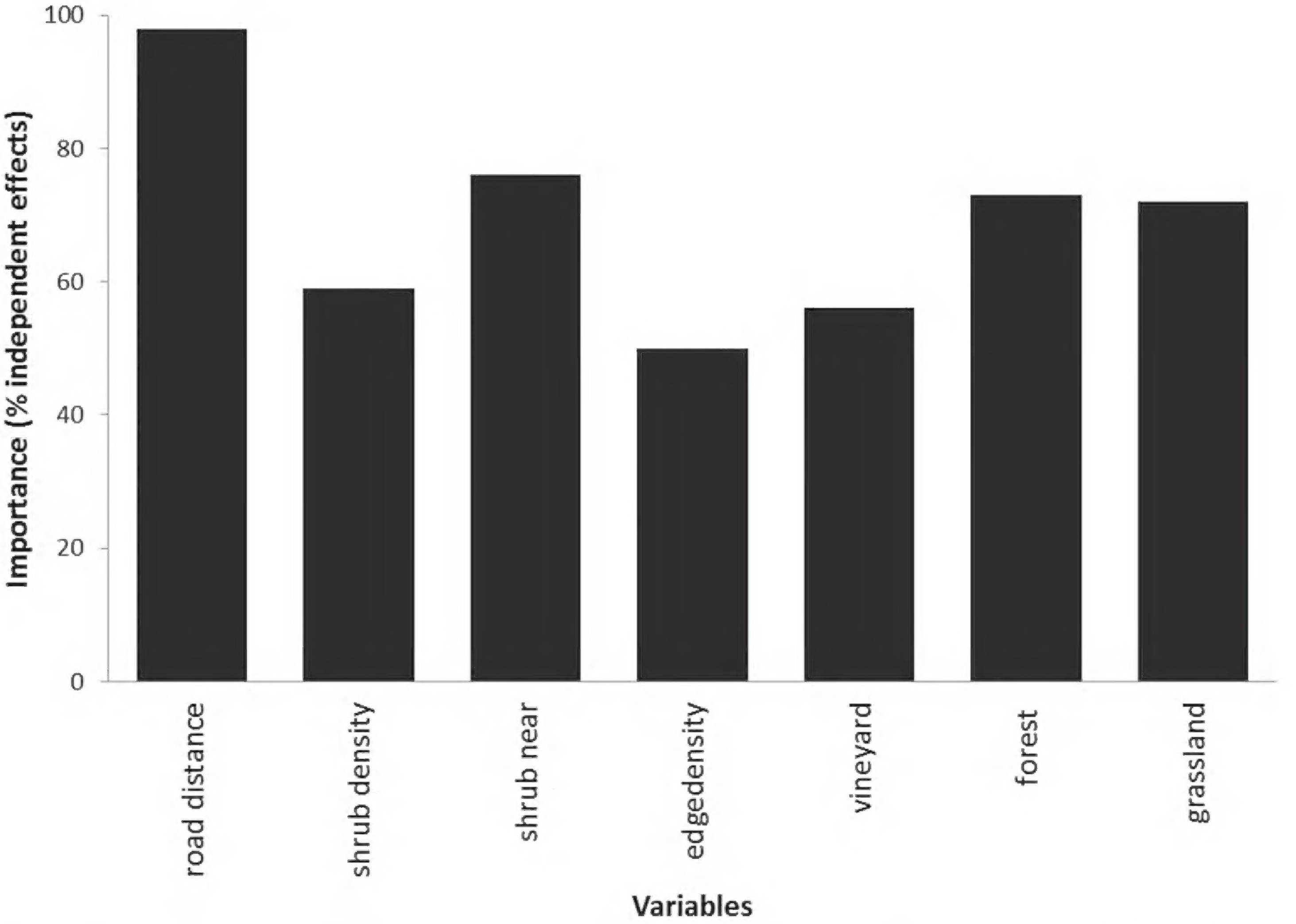

Figure 3. Measure of the effects of the independent variables entered in the best model, as a contribution to all of the possible models (hierarchical partitioning regression results). In the Y axis the percentage of goodness of fit for each variable.

the selection of suitable shrubs for nesting (Fig. 3). The relative importance of variables selected in the best model, were ranged from a maximum close to 0.98 for road distance, to a minimum of 0.51 for edge-density.

Discussion

Many studies on the breeding and feeding habitats of Lanius collurio have highlighted the importance of land use composition (Kuzniak and Tryjanowski 2000; Goławski and Goławska 2008, Girardello and Morelli 2012; Morelli 2012), with particular consideration given to patches' typology and their relative surface. However, the outcome of this work also highlighted the importance of landscape heterogeneity characteristics (shrub density, edge-density) and proximity to urban structures such as roads for the selection of the breeding habitats of species. The results of this work suggest that in extensive farmlands, the Red-backed Shrike seems to mainly select the shrubs nearest to roads for nesting. When available, the suitable shrubs that are closer to a road are chosen for this purpose. Other shrubs with similar characteristics (vegetal species, shape, surface, shrub density, proximity to other land use typologies, etc.), but which were

located away from roads, were not preferred. The hierarchical partitioning analysis demonstrated how road proximity made the greatest independent contribution when it comes to explaining the occupancy of suitable shrubs.

It is reasonable to argue that the presence of suitable shrubs and, at the same time, open spaces for hunting, both of which exist close to countryside roads, might represent the more favourable components for the breeding habitat selection of Red-backed Shrikes (Lefranc 1993; Farkas et al. 1997; Dinetti 1997; Morelli 2012). The main reason could be because, as recent studies have shown, road verges are used as network ecological corridors by various insects (Hobbs 1992; Vermeulen 1994; Vermeulen and Opdam 1995) that are potential prey for the Red-backed Shrike (carabids, butterfly, etc.). Preferring to take its prey on the ground, Lanidae can use an exposed road patch within its territory as an attractive place to do so. Furthermore, many roads are lined with power lines that are frequently used by birds as surveying and hunting posts (Bechet et al. 1998). However, the abundance of prey that Lanius collurio capture in these open spaces is certainly influenced by the state of surrounding habitats. Moreover, available suitable shrubs for nesting or perches were located in the vicinity of roads (34% of the total suitable shrubs were recorded as being less than 100m from the nearest road), perhaps due to a tendency encouraged by the long-standing local tradition of planting hedges and verges along country roads (these generally consist of *Crataegus* sp., *Prunus spinosa*, *Paliurus spina-christi*, *Ligustrum vulgare*, Morelli and Pandolfi 2011).

However, further research is needed to understand the real importance of each environmental variable in the selection of suitable shrubs by Red-backed Shrikes. This is mainly because many environmental variables could be strongly correlated, while others could be masked or hidden by other parameters (for example, the shape of the shrubs seems to be the same, whether close to or further away from the roads, but the shrubs nearest to the roads could also be pruned). Another important limitation of this work is due to the fact that only one landscape typology was sampled, meaning that the results are not really applicable to breeding habitat selection for the entire species, which is characterized by a relatively wide ecological plasticity in the choice of breeding habitat (Morelli 2012).

Furthermore, it would be important improve on our knowledge of the ecological offer of open spaces like countryside roads, which represent a low disturbance or low mortality risk to Shrikes, and may perhaps be good territory for hunting (Fernandez-Juricic et al. 2004). In this way, the results of this work could contribute to our understanding of the irregular distribution of the Red-backed Shrike in agricultural environments like those of central Italy. They could also provide useful indications for improving census techniques and planning conservation efforts for the species.

Acknowledgments

I would like to thank Yanina Benedetti, Maria Balsamo, Marco Dinetti, Marco Girardello and Mario D'Atri for their assistance and support with project planning. I am also grateful to ION Proofreading for the revision of the English version of this manuscript.

References

Akaike H (1974) A new look at the statistical model identification. IEEE Transactions on Automatic Control 19: 716–722. doi: 10.1109/TAC.1974.1100705

Anon (1999) S-PLUS 2000 Guide to Statistics, Vol. 1. MathSoft, Seattle, WA.

Bechet A, Isenmann P, Gaudin R (1998) Nest predation, temporal and spatial breeding strategy in the Woodchat Shrike Lanius senator in Mediterranean France. Acta Oecologica 19(1): 81–87. doi: 10.1016/S1146-609X(98)80011-8

Bennett AF (1991) Roads, roadsides and wildlife conservation: a review. In: Saunders DA, Hobbs RJ (Eds) Nature conservation 2: The role of corridors, 99–118. Surrey Beatty and Sons, Chipping Norton.

Bibby CJ, Burgess ND, Hill DA (1997) Bird Census Techniques. Academic press, London.

Box GEP, Cox DR (1964) An analysis of transformations. Journal of the Royal Statistical Society, Series B 26: 211–252.

Brambilla M, Casale F, Siccardi P (2007) Linee guida e indicazioni gestionali per la conservazione dell'Averla piccola Lanius collurio, specie d'interesse comunitario (Allegato I, Direttiva 79/409/CEE), in Lombardia. Relazione tecnica. Fondazione Lombardia per l'Ambiente, Milano.

Chevan A, Sutherland M (1991) Hierarchical Partitioning. The American Statistician 45: 90–96.

Dinetti M (1997) Averla piccola, Lanius collurio. In: Tellini Florenzano G, Arcamone E, Baccetti N, Meschini E, Sposimo P (Eds) Atlante degli uccelli nidificanti in Toscana (1982–1992) (Atlas of breeding birds in Tuscany). Quaderni del Museo di Storia Naturale di Livorno – Monografie 1, 308. [in Italian]

ESRI (2009) ArcGIS Desktop. Release 9. Environmental Systems Research Institute, Redlands, California, USA.

Farkas R, Horvath R, Pasztor L (1997) Nesting success of Red-backed Shrike, Lanius collurio in a cultivated area. Ornis Hungarica 7: 27–37.

Fernandez-Juricic E, Erichsen JT, Kacelnik A (2004) Visual perception and social foraging in birds. Trends Ecology and Evolution 19(1): 25–31. doi: 10.1016/j.tree.2003.10.003

Fielding AH, Bell JF (1997) A review of methods for the assessment of prediction errors in conservation presence/absence models. Environmental Conservation 24: 38–49. doi: 10.1017/S0376892997000088

Forman RTT (1995) Land mosaics: The ecology of landscapes and regions. Cambridge University Press, Cambridge.

Forman RTT, Alexander LE (1998) Roads and their major ecological effects. Annual Review of Ecological Systems 29: 207–231. doi: 10.1146/annurev.ecolsys.29.1.207

Forman RTT, Deblinger RD (2000) The ecological road-effect zone of a Massachusetts (USA) suburban highway. Conservation Biology 14: 36–46. doi: 10.1046/j.1523-1739.2000.99088.x

Foschi UF, Gellini S (1987) Atlante degli uccelli nidificanti in Provincia di Forlì. (Atlas of breeding birds in the province of Forlì). Maggioli, Rimini. [in Italian]

Girardello M, Morelli F (2012) Modelling the environmental niche of a declining farmland bird species. Italian Journal of Zoology 79(3): 434–440. doi: 10.1080/11250003.2012.666572

Goławski A, Goławska S (2008) Habitat preference in territories of the Red-backed Shrike Lanius collurio and their food richness in an extensive agriculture landscape. Acta Zoologica Academiae Scientiarum Hungarica 54: 89–97.

Guerriere G, Castaldi A (2006) Characteristics of nesting site, density and reproductive biology of Red-backed Shrike, Lanius collurio, in central Italy. Avocetta 29: 5–11. [in Italian]

Hobbs RJ (1992) The role of corridors in conservation: solution or bandwagon? Trends in Ecology and Evolution 7: 389–392. doi: 10.1016/0169-5347(92)90010-9

Kociolek AV, Clevenger AP, St Clair CC, Proppe DS (2011) Effects of road networks on bird populations. Conservation Biology 25(2): 241–249. doi: 10.1111/j.1523-1739.2010.01635.x

Kuzniak S, Tryjanowski P (2000) Distribution and breeding habitat of the red-backed shrike Lanius collurio in an intensively used farmland. Ring 22: 89–93.

Lefranc N (1993) Les Pies-grieches d'Europa, d'Afrique du nord et du moyen-Orient. Delachaux et Niestlé S.A., Lausanne, Paris.

MacNally R (2000) Regression and model-building in conservation biology, biogeography and ecology: the distinction between - and reconciliation of - 'predictive' and 'explanatory' models. Biodiversity and Conservation 9: 655–671. doi: 10.1023/A:1008985925162

McCullagh P, Nelder JA (1989) Generalized Linear Models. Chapman and Hall, London.

Meschini E, Frugis S (Eds) (1993) Atlante degli uccelli nidificanti in Italia. Supplementi alle Ricerche di Biologia della Selvaggina 20: 1–344.

Morelli F (2012) Plasticity of habitat selection by Red-backed Shrikes Lanius collurio breeding in different landscapes. The Wilson Journal of Ornithology 124(1): 51–56. doi: 10.1676/11-103.1

Morelli F, Pandolfi M (2011) Breeding habitat and nesting site of the red-backed shrike Lanius collurio in farmland of the Marche region, Italy. Avocetta 35: 43–49.

Morelli F, Santolini R, Sisti D (2012) Breeding habitat of Red-backed Shrike Lanius collurio on farmland hilly areas of Central Italy: is functional heterogeneity an important key? Ethology Ecology and Evolution 24: 127–139. doi: 10.1080/03949370.2011.635696

Mumme RL, Schoech SJ, Woolfenden GE, Fitzpatrick JW (2000) Life and death in the fast lane: demographic consequences of road mortality in the Florida Scrub-Jay. Conservation Biology 14: 501–512. doi: 10.1046/j.1523-1739.2000.98370.x

Olsson V (1995) The Red-backed Shrike Lanius collurio in southeastern Sweden: Habitat and territory. Ornis Svecica 5: 31–41.

PECBMS (2009) The State of Europe's Common Birds 2008. CSO/RSPB, Prague, Czech Republic.

R Development Core Team (2011) R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. ISBN 3-900051-07-0, URL http://www.R-project.org/

Reed RA, Johnson-Barnard J, Baker WL (1996) Contribution of roads to forest fragmentation in the Rocky Mountains. Conservation Biology 10: 1098–1106. doi: 10.1046/j.1523-1739.1996.10041098.x

Reijnen R, Foppen R, Meeuwsen H (1996) The effects of traffic on the density of breeding birds in Dutch agricultural grasslands. Biological Conservation 75: 255–260. doi: 10.1016/0006-3207(95)00074-7

Reijnen R, Foppen R, ter Braak C, Thissen J (1995b) The effects of car traffic on breeding bird populations in woodland. III. Reduction of density in relation to the proximity of main roads. Journal of Applied Ecology 32: 187–202. doi: 10.2307/2404428

Reijnen R, Foppen R, Veenbaas G (1995a) Disturbance by traffic of breeding birds: evaluation of the effect and considerations in planning and managing road corridors. Biodiversity and Conservation 6(4): 567–581. doi: 10.1023/A:1018385312751

Spellerberg IF (1998) Ecological effects of roads and traffic: a literature review. Global Ecology and Biogeography Letters 7: 317–333. doi: 10.2307/2997681

Trombulak SC, Frissell CA (2000) Review of ecological effects of roads on terrestrial and aquatic communities. Conservation Biology 14: 18–30. doi: 10.1046/j.1523-1739.2000.99084.x

Tryjanowski P, Golawski A (2004) Sex differences in nest defence by the redbacked Shrike Lanius collurio: effects of offspring age, brood size, and stage of breeding season. Journal of Ethology 22: 13–16. doi: 10.1007/s10164-003-0096-9

Tryjanowski P, Kuzniak S, Diehl B (2000) Does the breeding performance of the Red-backed Shrike, *Lanius collurio*, depend on nest site selection? Ornis Fennica 77: 137–141.

Tryjanowski P, Kuzniak S (1999) Effect of research activity on the success of Red-backed Shrike, Lanius collurio nests. Ornis Fennica 76: 41–43.

Van der Zande AN, ter Keurs WJ, Van der Weijden WJ (1980) The impact of roads on the densities of four bird species in an open field habitat - evidence of a long-distance effect. Biological Conservation 18: 299–321. doi: 10.1016/0006-3207(80)90006-3

Vermeulen HJW (1994) Corridor function of a road verge for dispersal of stenotopic heathland ground beetles carabidae. Biological Conservation 69(3): 339–349. doi: 10.1016/0006-3207(94)90433-2

Vermeulen HJW, Opdam P (1995) Effectiveness of roadside verges as dispersal corridors for small ground-dwelling animals: a simulation study. In: Landscape Urban Planning 31: 233–248. doi: 10.1016/0169-2046(94)01050-I

Walsh C, Mac Nally R (2008) Hier.Part: Hierarchical Partitioning, In R Package Version 1.0-3.

Yosef R (1994) Conservation commentary: Evaluation of the global decline in the True Shrike, family Lanidae. The Auk 111(1): 228–233. doi: 10.2307/4088532